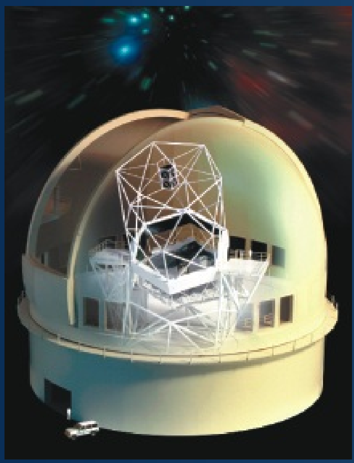
European Northern Observatory (ENO)

Canary Islands, a priviledged site for astronomical observations

ENO, Europe's Organisation for Astronomy in the North

An "astronomical reserve" protected by Law

Introduction



The “Observatorio del Roque de los Muchachos” (ORM) on La Palma and the “Observatorio del Teide” (OT) on Tenerife, combine world class facilities for night and solar time studies. At present, there are telescopes and other astronomical instruments from nineteen countries (Armenia, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Poland, Portugal, Russia, Spain, Sweden, Taiwan, Ukrania, the United Kingdom, and the United States). This group, together with the scientific and technical facilities of the “Instituto de Astrofísica de Canarias” in Tenerife, constitute the European Northern Observatory (ENO), shortly to be boosted by the coming into service in 2003 of the 10.4 m optical-infrared Gran Telescopio Canarias (GTC) and with the facilities of the Joint Astrophysics Centre (La Palma).

Historical Perspective

The quality of the Canarian skies for observational astronomy has long been recognised. As far back as 1856, the Astronomer Royal for Scotland conducted astronomical experiments on the mountain summits of the island of Tenerife. He concluded that the skies above the Canary Islands were ideal for astronomical observations (Teneriffe: An Astronomer's Experiment, Piazzi Smyth, 1858). These early conclusions were later confirmed by, among others, Jean Mascart in 1910 during an expedition to study Halley's Comet (Jean Mascart, Photographies de la comète Halley, Comptes rendues de l'Academie des Sciences, 1910). Mascart reported that the cold ocean currents surrounding the Canary Islands in combination with the trade winds, provide a unique stable climate with little atmospheric turbulence. He also noted that the inversion layer, where low-altitude clouds form, generally remains well below the mountain peaks and has the added advantage of blocking artificial light sources from populated areas (J. Mascart, Impressions et Observations dans un voyage à Teneriffe, Ernest Flammarion París, 1912).

In 1968 a collaboration was established among a number of European institutes to establish an optimal site for solar observations. An extensive site-testing campaign, comparing over 40 prospective sites, identified La Palma and Tenerife as the best observing sites (Vistas in Astronomy, 28, 437,1985).

This international collaboration was formalized in 1979 with the signing of the International Agreements ("Acuerdo y Protocolo de Cooperación en Astrofísica"). The astronomical quality of the Canarian Observatories is guaranteed under a specific law approved in 1988 (known as the "Ley del cielo"). This makes the IAC's Observatories a legally protected site (in effect an astronomical "reserve") where continued dark skies, low radio frequency fields, and control over other sky-polluting effects - including aircraft flight paths - are guaranteed.

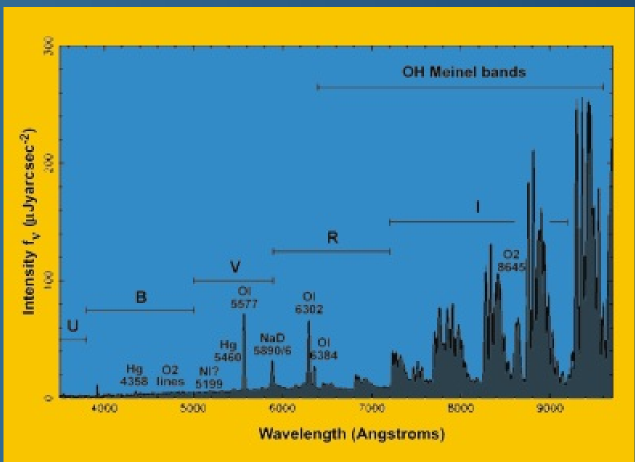
The IAC has a Sky Quality Protection Unit ("Oficina Técnica para la Protección de la Calidad del Cielo" - OTPC) whose objective is the permanent enforcing of this law (http://www.iac.es/galeria/fpaz/ofic2.htm).

Sky Background

The brightness of the moonless night sky above La Palma has been measured from hundreds of CCD images taken with the 2.5-m Isaac Newton and 1.0-m Jacobus Kapteyn Telescopes between 1987 and 1996. The median sky brightness, in units of magnitude per arcsec^2, at high elevation, high galactic latitude and high ecliptic latitude, at sunspot minimum, is B=22.7, V=21.9, R=21.0, U~22.0, I~20.0. As with other dark sites, the main contributions to sky brightness are airglow and zodiacal light.

The contribution of light polution to the continuum brightness at the zenith is <0.03 mag in all bands. The Sodium D emission brightens the sky in both V and R broad bands by about 0.07 mag. Total contamination (line plus continuum) at zenith is <0.03 mag in U, ~0.02 in B, ~0.10 in V, and ~0.10 in R (ING Technical Note 115, 1998).

The effectiveness of the sky protection act on La Palma was put to the test when on the night of 24 June 1995 virtually the entire public lighting on the island was switched off for one hour for this special purpose. The only serious changes were seen in the strength of the sodium D lines scattered from the night sky, indicating that light polution is negligible and effectively controlled.



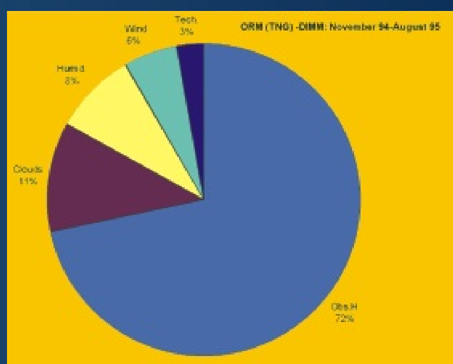
Typical spectrum of the La Palma sky on a moonless night. Most of the distinctive features of the night-sky spectrum are due to airglow. The NaD emission at 5890/6 A° is partly due to street lighting, while the mercury emission at 4358, 5461 A° is wholly so. With the exception of the 8645-A° O_2 line, the features dominating the spectrum redward of 6500 A° are the Meinel rotation-vibration bands of OH. (New Astronomy Reviews, 42, 503 (1998)).

Useful observing time and mean meteorological parameters

Over the past 10 years of operation of the 4.2-m William Herschel Telescope the all-year average weather down time was 27% of all nightly hours. This weather down time comprises all time, when due to cloud cover, high winds (above 80 km/h), humidity (over 90%), or snow and ice, observations could not take place.

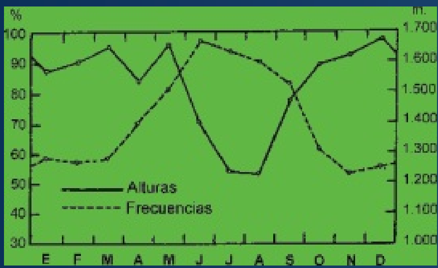
The Carlsberg Meridian Telescope (CMT) weather related downtime statistics, which is closer to the so-called useful-time, is 79% (ESO Technical Note on Site Quality Assessment: Observatorio del Roque de los Muchachos, La Palma, Islas Canarias (1995), from Royal Greenwich Observatory; CAMC Downtime Statistics 1984-1994; transmitted by M. Buontempo, Oct.95)

On 78% of the days in the year, the atmospheric transparency was good (within 90% of the theorical transmission of a pure, dry atmosphere observed from a height of 2400 m) (Vistas in Astronomy, 28, 449 (1985)).



Percentages of useful observed and lost night time at the Telescopio Nazionale Galileo site (A&A Suppl.Ser. 125, 183 (1997)).

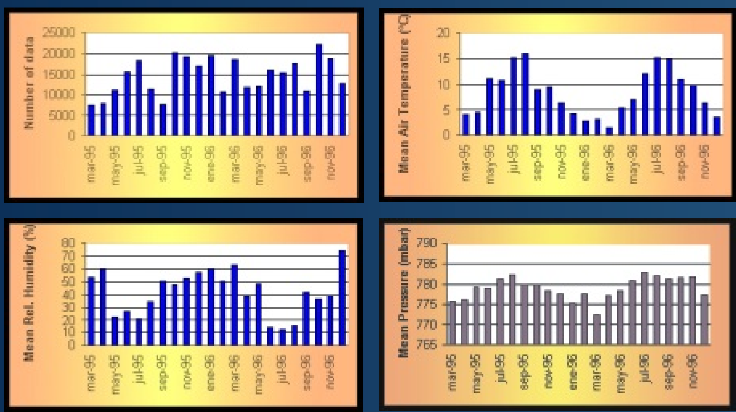
Meteorological Parameters



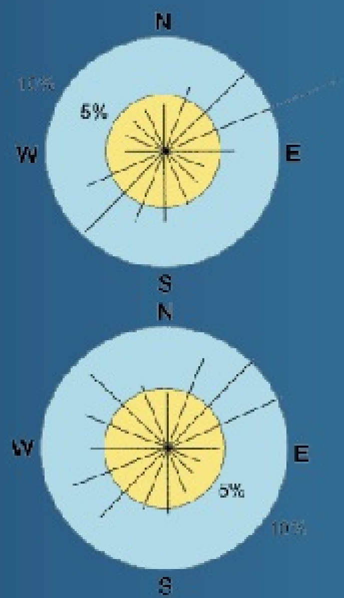
Annual variation of the scale height and frequency of the sea clouds in Tenerife. Taken from Font-Tullot (1956) "The weather in the Canary Islands" (in spanish) Madrid, Servicio Nacional de Meteorología, Publ.Ser. A 26.

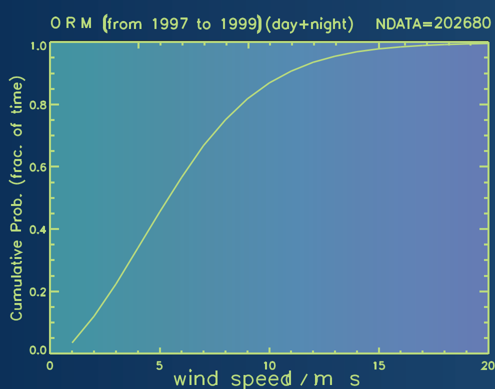
Roque de Los Muchachos Observatory (ORM)

N. of data, air temperature, relative humidity, barometric pressure



Nocturnal monthly statistics for the GTC site from 1995 to 1996: number of night time data for each month, mean nocturnal monthly values of air temperature, relative humidity and atmospheric pressure (in mbar) at 2 m above ground level. (New Astronomy Reviews, 42, 417 (1998)).

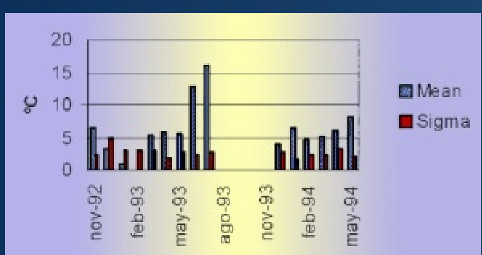




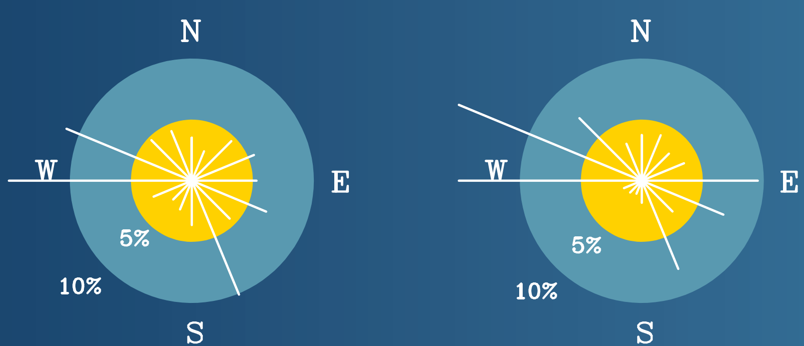
Cummulative frequency of wind speed at ORM.

Nocturnal and daytime windroses from February 1995 to December 1996 at the GTC site at the ORM (New Astronomy Reviews, 42, 417 (1998)).

Teide Observatory (OT)



Mean night time air temperature at the OT. A&A, 2000.

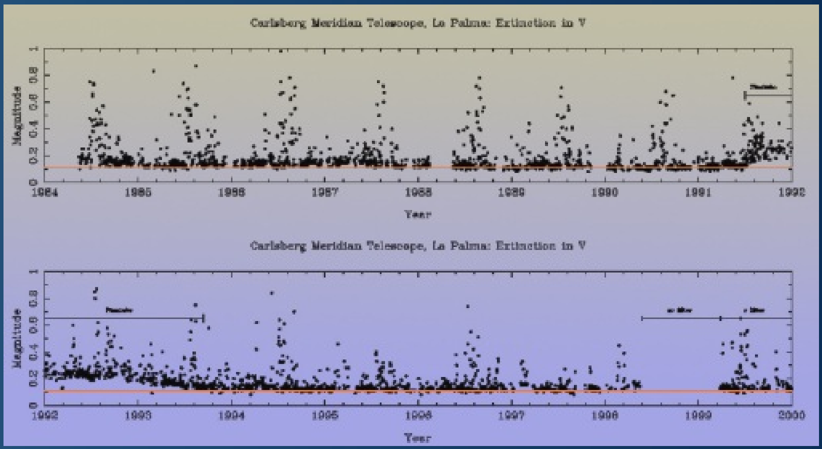


Nocturnal and daytime windroses at the OT from November 1992 to May 1994, A&A, 2001.

Atmospheric Transmission

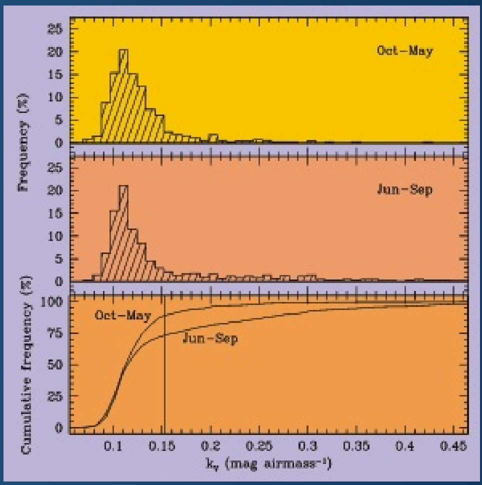
Long-baseline extinction values for ORM have been measured by the Carlsberg Meridian Telescope in the V band (and more recently in the Sloan r' band). During photometric, dust-free nights median extinction is 0.19 mag (at 480 nm); 0.09 mag (at 625 nm) and 0.05 mag (at 767 nm).

The extinction coefficients show that on clear days (denoted coronal-pure) the extinction values at 680 nm are never higher than about 0.07-0.09 mag airmass^{-1}, while on dusty days (diffuse-absorbent) they are always higher (New Astronomy Reviews, 42, 521 (1998)).



From observations of about 50 photometric standards, the Carlsberg Meridian Telescope provided nightly values of atmospheric extinction in V for ORM. The data is split up into yearly files going back as far as 1984. The most recent file is that for 2000 January - May. From the end of 1999 March this differs from previous years as it is derived from the new CCD camera which works in the Sloan r' band.

Short periods of higher extinction due to Saharan dust in the atmosphere is experienced at times during the year, particularly in summer (see Murdin 1986, ING La Palma Technical Note 41 and PASP, 2001). This dust extinction is essentially independent of wavelength, unlike normal atmospheric extinction (New Astron Rev 42, 521). A typical dust storm lasts one to a few days to disperse. In summer over 75% of the nights are free of dust, while at other times of the year over 90% of the nights are dust free (New Astron. Rev. 42, 529). Extinction in V is less than 0.2 mag on observing nights over approximately 88% of the nights, and extinction in excess of 0.5 mag only occurs less than 1% of the nights.

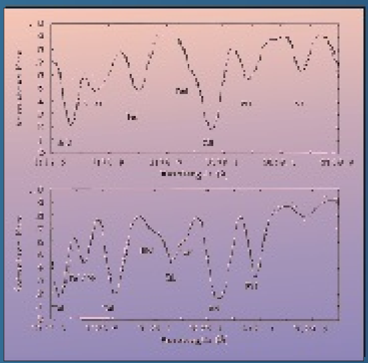


Frequency of extinction over the ORM during winter (top) and summer period (centre). In both cases the modal value is found at 0.11 mag/airmass. Their corresponding cumulative frequencies are also shown (bottom). The vertical line indicates the extinction coefficient limit for dusty nights, $k_v \geq 0.153$ mag/airmass (PASP 2001).

λ (nm)	Clear days (a)	Dusty days(b)
450	2.132+-0.105	1.028+-0.042
500	1.333+-0.025	1.011+-0.015
770	1.159+-0.033	0.999+-0.009
870	1.026+-0.029	1.009+-0.012

Slopes of the extinction lines $K_\lambda = a + bK_{680}$ from New Astron. Reviews, 42, 521 (1998).

Sky Quality in the Ultraviolet



Fit of synthetic spectra (dotted lines) to two regions surrounding the OH lines in the high-resolution integrated-flux solar atlas of Kurucz et al. (1984; solid lines). The locations of the different OH lines are indicated while question marks are associated with cases without a clear line identification. APJ, 507, 805 (1998).

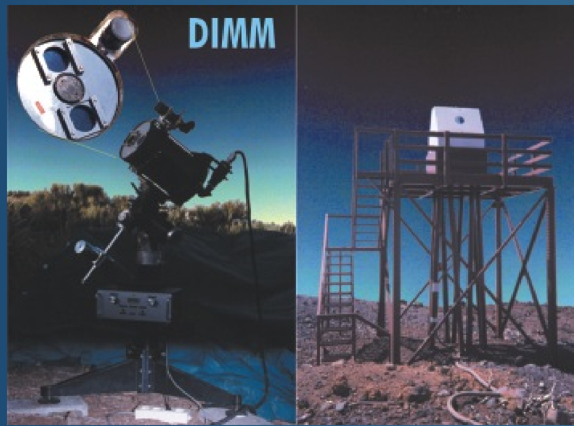
Image Quality and Atmospheric Turbulence

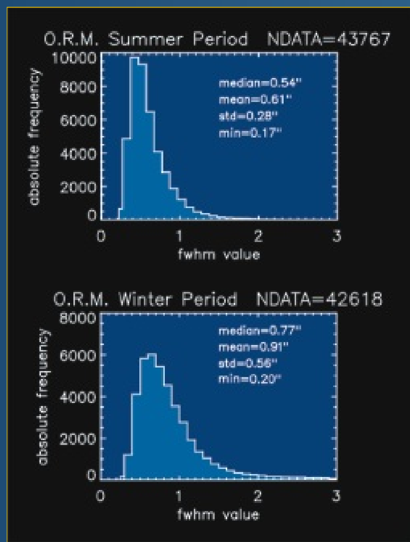
Good intrinsic site seeing quality is important, if not crucial to most astronomical observations. In particular when using modern techniques such as adaptive optics the free atmosphere seeing quality and turbulence characteristics are a key parameter in the success of the observations. It is exactly in the area of image quality for both night time and solar observation where the Canarian observatories excel, as indicated by some outstanding high spatial resolution results obtained with the telescopes. Quantitative seeing measurements are given by differential image motion monitors according to a well established theory and a concept which makes them insensitive to optical aberrations and wind shake of the instrument.

A number of site testing campaigns now provide objective evidence for the quality of the site. Using a Differential Image Motion Monitor (PASP, 107, 265 ,(1995)) the free atmosphere seeing was measured over long time intervals and at different places (at times simultaneously) at the ORM. These results show that the mean seeing over the years is 0.67 arcsec.

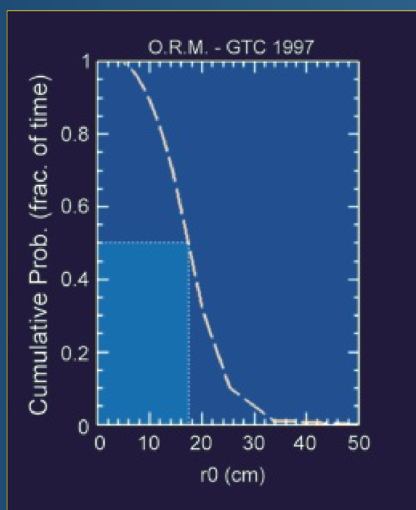
Under typical seeing conditions, image quality does not depend on the particular location and shows a high degree of homogeneity over the whole Observatory. (A&A, (1998), New Astron. Reviews, 42, 409 (1998)).

Many new instruments and intensive site-testing campaigns have been undertaken in recent years, however very little long-term data is available yet. Even very good observatories - such as Mount Graham or Hawaii - lack this kind of database, which seems imperative for a proper site comparison to be done. Only La Silla and Paranal and ORM have systematic seeing measurements taken with calibrated instruments. (Astron. & Astrophys. Suppl. Ser., 125, 183 (1997)).





A seasonal variation is noticeable, better seeing conditions appearing during the summer, coinciding with a well-defined inversion layer due to the high prevalence of trade winds. During the summer, 50% of the time seeing is better than 0.54", value which reaches down to 0.4-0.46" during June-July (Astron. & Astrophys. Suppl. Ser., 125, 183, 1997).



Cummulative frequency of seeing measurements (55545 data) at the GTC site. For 50% of all cases, the seeing value is smaller than 0.58arcsec (r_0 larger than 17.4cm).

YEAR	1995/1996	1997	1998	1999
Ndata	87978	55545	50661	53178
Min (")	0.18	0.20	0.20	0.17
Mean (")	0.75	0.66	0.71	0.78
std (")	0.40	0.30	0.34	0.40
Median (")	0.65	0.58	0.63	0.68
< 0.5 "	22%	31%	23%	17%
< 1 "	84%	89%	88%	82%
> 2 "	2%	1%	1%	2%

Seeing measurement results obtained at the GTC site from 1995 to 1999, from A&A, 2000 (in preparation). Also, "Informe final para la Ubicación del Gran Telescopio de Canarias", (1997)

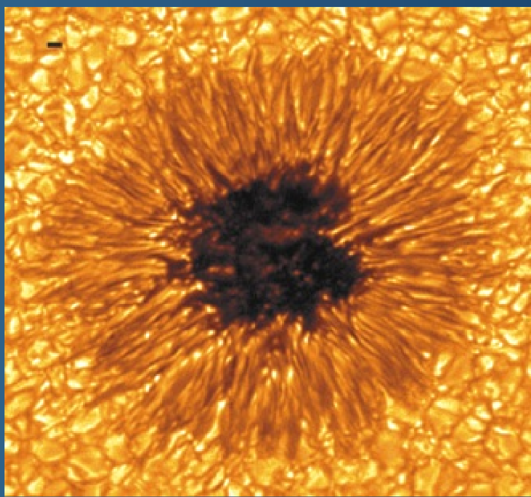
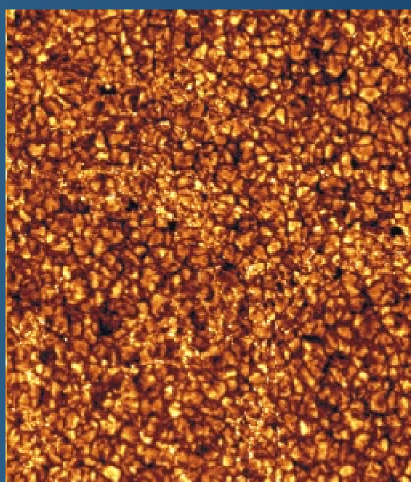
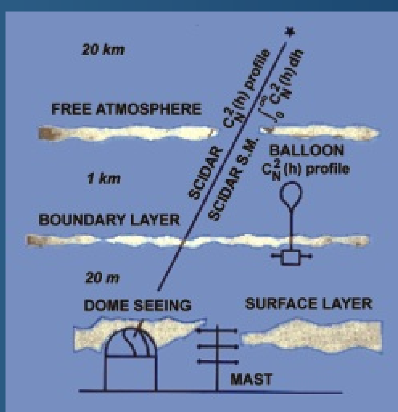


Image of a sunspot. The mark represents 1 arcsec (equivalent to 725 km on the surface of the Sun). The image (611 x 559 pixels, each pixel measuring 0.062 arcsec) was corrected for atmospheric and instrumental degradation (from ApJL, 447, L133 (1995)).



Twenty-five per cent of a 2000x2000 pixel G-band (430 nm) image of the Sun's surface recorded at the SVST (La Palma) using real -time frame and a 10 ms integration at exceptionally high resolution from New Astronomy Reviews, 42, 481 (1998) , back front page-.



Sketch of the instrumental set-up used in the intensive site testing campaign (A&A, 257, 811 (1992)). Atmospheric turbulence contribution of the surface layer, boundary layer and free atmosphere during the whole night of July 22 1990, as measured respectively with mast, balloons and Scidar.

The seeing statistics gathered at ORM place the Observatory among or better than other known excellent sites (Paranal and La Silla) where seeing statistics are available. (A&A Suppl. Ser., 125, 183, 1997).
These results coincide with those obtained at the ORM for JOSE (Joint Observatories Seeing Evaluation), a project initiated by the United Kingdom as part of an adaptive optics (OA) programme. Turbulence outer scale statistics was obtained for ORM by JOSE (MNRAS, 309, 379 (1999)). The mean value of L_0 is 15 meters.

Several intensive site-testing campaigns have been carried out with simultaneous techniques, equipped balloon soundings (CN2 profiles, water vapour, wind velocity and direction) + SCIDAR at the NOT, DIMMs and meteorological towers equipped with microthermal sensors. The aim was to characterize the Observatory for updated programmes and to evaluate the contribution of the free atmosphere, the boundary layer and the surface layer to image degradation.

From balloon soundings, quantities related to high angular resolution astronomy, such as speckle lifetime and the isoplanatic angle, as well as the integrated water vapour content (relevant to IR astronomy), have been obtained. The isoplanatic angle is larger than two arcsec and in most cases the number of well defined turbulent layers is very small, so that multiconjugate adaptative optics is applicable (A&A, 284, 311 (1994)).

The FREE ATMOSPHERE has an exceptionally low contribution (0.4"), comparable to the values measured at La Silla (0.34") and Mauna Kea (0.46"). The SURFACE LAYER (from 6 up to 12m) is almost negligible (0.08").

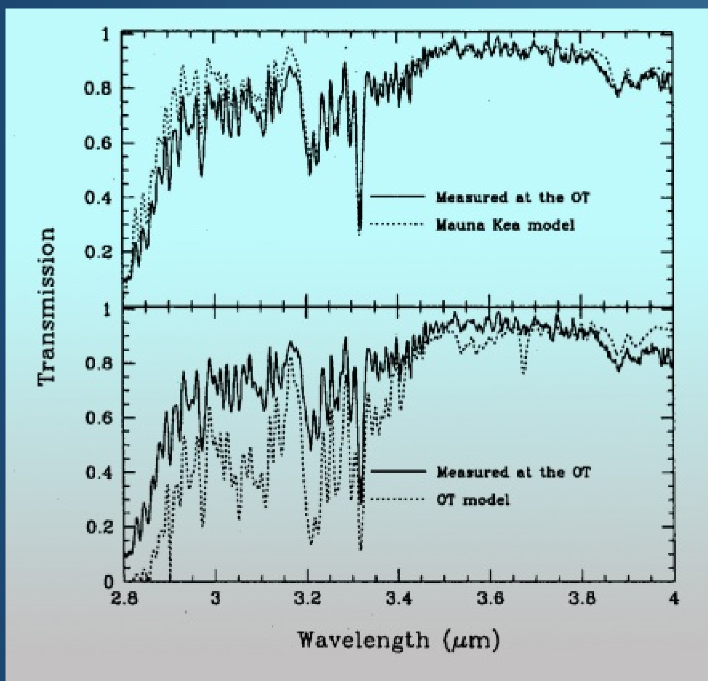
Infrared sky quality - Extinction and water vapour content.

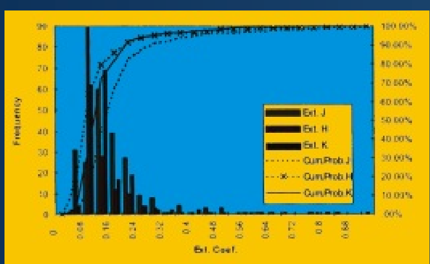
In the case of observations at (mid-)IR wavelength to a large extent the atmospheric water vapor content determines the sky transparency. High mountain peaks (Hawaii) and arid regions (Atacama) are therefore ideal sites for such observations. An extensive site testing campaign at ORM - in preparation of the construction of the 10-m GTC telescope - shows that this site is also highly attractive for its low water vapour content. Sky monitors and radiometers were used. Some 39% of the nights during the year have a water vapour column of less than 3mm per unit airmass. A significant 10% of all observing time the waver vapour column is lass than 1 mm.
(New Astronomy Reviews, 42, 537 ,1998)

Direct measurements using balloon soundings give a mean value of precipitable water vapour content of 3.4 mm with a minimum of 1.9 mm.(A&A, 284, 311 (1994)).

Evaluation of the infrared quality of the sky on high and dry mountain sites has shown that the Canaries is the best infrared site in Europe (Ap.Lett.Comm., 28, 171 ,1991).

L-band transmission measured at the OT compared with the model (ATRAN) transmission for the OT and Mauna Kea (New Astron. Rev., 42,533). Note that the measured L spectrum at the OT is similar to a spectrum corresponding to the height of Mauna Kea (4100m) rather than to the height of the OT (2400m) .





Histograms and cumulative probabilities for the J, H and K extinction coefficients (New Astron. Rev., 42, 543 (1998)).

Statistical summary of the atmospheric extinction coefficients.

	E_J	E_H	E_K	$E_J(90\%)$	$E_H(90\%)$	$E_K(90\%)$
Mean	0.161	0.099	0.120	0.126	0.069	0.097
Standard error	0.009	0.008	0.006	0.004	0.003	0.003
Median	0.127	0.065	0.093	0.117	0.062	0.087
Mode	0.086	0.065	0.080	0.086	0.065	0.080
Variance	0.017	0.013	0.008	0.003	0.001	0.001
Kurtosis	13.245	20.299	17.022	-0.043	0.836	0.353
Skewness	3.259	4.022	3.578	0.745	1.048	0.851
Minimun	0.037	0.007	0.020	0.037	0.007	0.020
Maximun	0.965	0.888	0.748	0.265	0.184	0.191
N	186	186	186	167	167	168

Filter	WHT WIRCAM *		WHT 4-Channel	TCS CAIN
J	16.6	15.6		15.5
H	14.4	13.9		13.5
K	11.0	11.4	11.5	12.5
L	2.9	3.4	5 to 3.5	–

* Numbers from the WHIRCAM handbook measured in 1995 February (left column) and 1995 June (at full moon).

Measured sky brightness in mag arcsec $^{-2}$ (New Astron. Rev., 42,533).

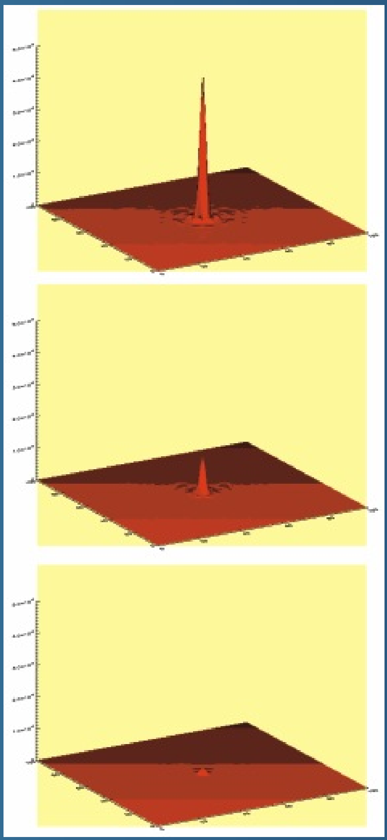
Programmes for optimizing Astronomical observing and capitalizing on the quality of our skies.

The different countries and institutes involved in the Canarian Observatories undertake programmes of many types, ranging from scientific research to more routine infrastructure investigations aimed at avoiding the degradation of observations.
It is of fundamental importance to know the contribution of the turbulence layers. It is also necessary to study the relevant parameters for the development of high spatial resolution and adaptive optics (the isoplanatic angle and the speckle lifetime). These are the objectives of the HIGH RESOLUTION projects now under way, among which could be mentioned JOSE, headed by the Anglo-Dutch team at the ORM.

In the near future, routine turbulence profiles will be provided using SCIDAR attached to the telescopes (New Astronomy Reviews, 42, 405 (1998)).

Turbulence profile and atmospheric stability measurements are vital for determining the input parameters of complex adaptive optics (AO) systems. There are large areas of sky with a lack of sufficiently bright stars to reference for the AO correction. For these "empty" areas of sky it is necessary to create artificial point sources (laser guide stars).

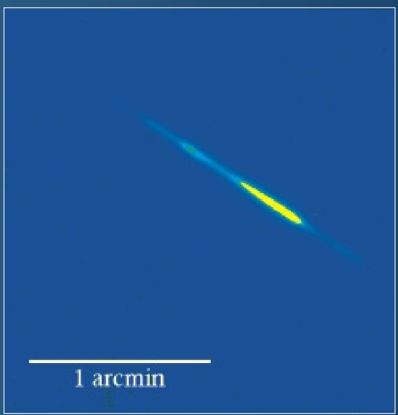
The LASER GUIDE STAR Project is framed within the European Community Programme and involves several countries, including France, the UK, Holland and Spain.



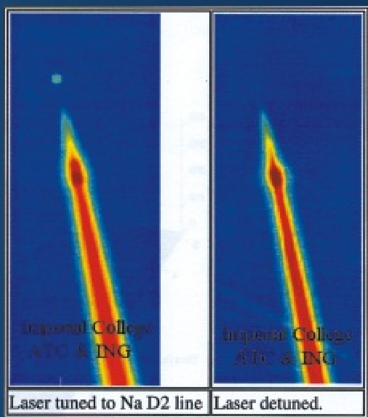
Images that would be obtained using an adaptive optics system ($\lambda = 1.65\ \mu$) with a deformable mirror with 100 actuators on a GTC-type telescope for three different values of seeing: 0.5 arcsec, 1.0 arcsec and 1.5 arcsec. The plate-scale is the same for all three images.

First sodium laser beacon at ORM

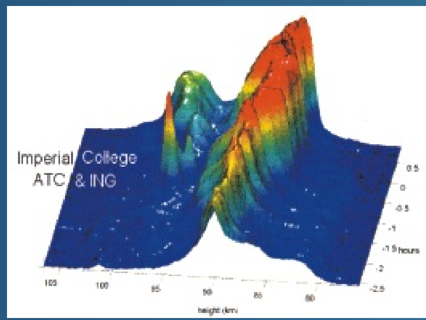
http:/op.ph.ic.ac.uk/jkt_lgs/



Observing the sodium beacom from the JKT, 163 meters from the launch site. The image shows the long streak through the sodium layer created by the laser, with brighter emissions from those parts of the layer more abundant in sodium (MNRAS, 318, 139 (2000)).



A number of experimental sodium laser firing tests were carried out. It was shown that sufficient sodium is indeed present to produce an adequately bright guide star. Temporal variation by a factor of two were recorded, as well as seasonal variations similar to those measured elsewhere, with higher sodium atom density during winter. The sodium density measured in summer was 1.6 10^9 atoms/cm^2. The typical height of the sodium layer is approximately 90 km; at times the profile was seen to split into two layers.
Preliminary tests indicate that bright (< 10 mag) Sodium laser guide stars can be created over the Observatory with moderately high-power lasers (MNRAS, 318, 139 (2000)).

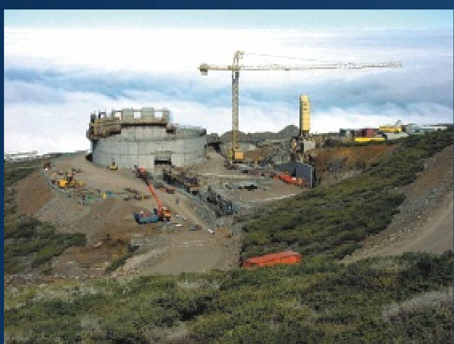


The Sodium profile variation at ORM. Data from one half night (22nd September 1999). The figure shows a large, slow variation in the shape and total area of the sodium profile, as well as a sporadic event of high sodium concentration, lasting a about 15 minutes (from MNRAS, 318, 139 (2000); see also http:/op.ph.ic.ac.uk/jkt_lgs/).

Snapshots of the construction of GTC at ORM. First light is due in 2003.

May 2000

October 2000



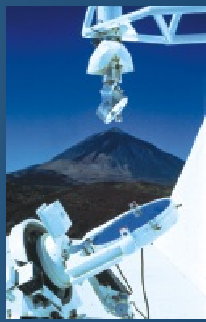
December 2000

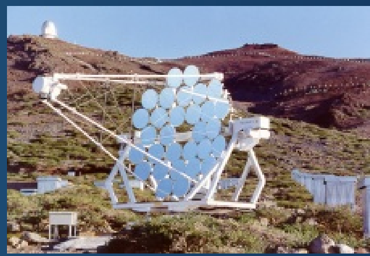
December 2000

"Seeing prediction" programmes, developed by French and Italian teams in collaboration with the meteorological offices, are also under way. These projects will enable "flexible scheduling" routines to be implemented in the near future in order to optimize the use of telescope time by allocating observing programmes to prevailing atmospheric conditions throughout the night.

A workshop on "Site Properties of the Canarian Observatories" was held in La Palma in October 1997. Attended by about one hundred astronomers and engineers from countries running telescopic installations at ENO, thirty invited contributions were presented, all of which are included in a special issue of New Astronomy Reviews. The initiative to organize a workshop specifically focused on results pertaining to the quality of the site was a natural step following the work of previous years. In 1985, the journal Vistas in Astronomy dedicated a special issue to the Canarian Observatories coinciding with their official inauguration.

Only at first-class sites, where the intrinsic excellence of the sky quality can be established beyond doubt, is it worthwhile investing in the application of all the necessary techniques for ensuring perfect observing conditions. The Canarian Observatories, along with other sites such as La Silla and Paranal in Chile and Mauna Kea in Hawaii that have built or are planning the construction of new-generation large telescopes, cannot afford to lag behind in the study of site properties. For this reason, new techniques have been developed for the study of the atmosphere and new observing modes are being introduced that will enable this gift of Nature to the astronomical community to be exploited to the full.





References

- Vistas in Astronomy, 1985, Special Issue "The Observatories of the Canaries", Vol. 28, Ed.P. Murdin & P. Beer, Pergamon Press

- New Astronomy Reviews, 1998, Special Issue "Site Properties of the Canarian Observatories", Vol. 42, , Ed. C. Muñoz-Tuñón, Elsevier

Benn C.R. & Ellison S.L. , 1998, "Brightness of the night sky over La Palma", New Astronomy Review, 42, 503

Brandt P.N. & Righini A., 1985, " The JOSO site testing campaigns in the Canary Islands", Vistas in Astronomy, 28, 437

Font-Tullot I., 1956, "The weather in the Canary Island" (in spanish) Madrid, Servicio Nacional de Meteorología, Publ.Ser. A 26

Fuensalida J.J. & Alonso A., 1998, "Characterization of the atmospheric extinction in the near infrared at the Teide Observatory", New Astron. Rev., 42, 543

Guerrero M.A. et al., 1998, "Extinction over the Canarian Observatories: the limited influence of Saharan dust", New Astron. Rev., 42, 529

Guerrero M.A. et al., 2001, PASP (in press).

Hammersley P.L., 1998, "Infrared quality of the Canarian skies", New Astron. Rev., 42, 533

Israelian G., García López R., & Rebolo R., 1998, "Oxygen abundances in unevolved metal-poor stars from near-UV OH lines", APJ, 507, 805

Jiménez A. & González Jorge H., 1998, "The grey behaviour of Saharan dust", New Astron. Rev., 42, 521

Kidger M., Rodríguez-Espinosa J.M., del Rosario J.C. & Trancho G., 1998, "Water vapour monitoring at the Roque de los Muchachos Observatory (1996-1998)", New Astron. Rev., 42, 537

Klueckers V.A. et al., 1998, "Profiling of atmospheric turbulence strength and velocity using a generalised SCIDAR technique", A&AS, 130, 141.

Kurucz R.L., Furenlid I., Branlt J. & Testerman L., 1984, "Solar flux Atlas from 296 to 1300 nm", NOAO Atlas 1

Mahoney T., Muñoz-Tuñón C. & Varela A.M., 1998, "GTC site-testing campaign: meteorology", New Astron. Rev., 42, 417

Mascart, J., 1912, "Impressions et Observations dans un voyage à Teneriffe", Ernest, Flammarion, Paris

Michaille L. et al., 2000, "A laser beacon monitoring the mesospheric sodium layer at La Palma", M.N.R.A.S., 318, 139.

Muñoz-Tuñón C., Varela A.M. & Mahoney, T, 1997, "Informe final para la Ubicación del Gran Telescopio de Canarias"

Muñoz-Tuñón C., Vernin, J. & Varela, A.M., 1997, "Night-time image quality at Roque de los Muchachos Observatory", A&AS, 125, 183

Muñoz-Tuñón C., Varela A.M. & Mahoney, T, 1998, "Homogeneity of image quality at the Roque de los Muchachos Observatory", New Astron. Rev. 42, 409

Murdin P., 1985, "Nighttime skies above the Canary Islands", Vistas in Astronomy, 28, 449

Sarazin M., 1995, ESO Technical Note on Site Quality Assessment: Observatorio del Roque de los Muchachos, La Palma, Islas Canarias

Selby M. & Mampaso, A. , 1991, "Infrared Observations in the Canary Islands", Ap.Lett.Comm., 28, 171

Shand M. & Scharmer G.B., "The Swedish Vacuum Solar Telescope data-acquisition and control systems", 1998, New Astron. Rev., 42, 481

Smyth, C.P., 1858, "Teneriffe, an Astronomer's Experiment: or Specialities of a residence above the clouds" , Lovell Reeve

Sobotka M., Bonet J.A., Vázquez M. & Havslmeier, A., 1995, "On the dynamics of bright features in sunspot umbrae", ApJL, 447, L133

Varela A.M., Muñoz-Tuñón C. & Saviron C., "Image Quality at the Teide Observatory", A&A , 2000 (in preparation)

Vernin J. & Muñoz-Tuñón C. 1995, "Measuring Astronomical Seeing: the DA/IAC DIMM", PASP, 107, 265

Vernin J. & Muñoz-Tuñón C., 1994, "Optical seeing at La Palma Observatory. II. Intensive site testing campaign at the Nordic Optical Telescope", A&A, 284, 311

Vernin J., Masciadri E. & Avila R., 1998, "New approaches in atmospheric optics: generalized scidar and seeing prediction", New Astron. Rev., 42, 405

Vernin J. & Muñoz-Tuñón C., 1992, "Optical seeing at La Palma Observatory. I. General guidelines and preliminary results at the Nordic Optical Telescope", A&A, 257, 811

von der Lühe O., 1998, "High-resolution observations with the German Vacuum Tower Telescope on Tenerife", New Astron. Rev., 42, 493

Wilson, R., 1998, " Results of the JOSE site evaluation project for adaptive optics at the William Herschel Telescope", New Astron. Rev., 42, 465

Wilson R., N. O´Mahony, C. Packham, M. Azzaro, 1999, "The seeing at the William Herschel Telescope", M.N.R.A.S., 309, 379

Brochure Editor: Dr. C. Muñoz-Tuñón
(Chair of the Site Properties
Committee of CCI;
PI of the Sky Quality Group of the IAC)

Co-Editors: Dr. R.J. Rutten
(International Scientific Committee;
ING Director)
Dr. A.M. Varela
(Sky Quality Group of the IAC)

Acknowledgements: GTC Optics Group
(http://www.gtc.iac.es/) and IAC linguistic revision service

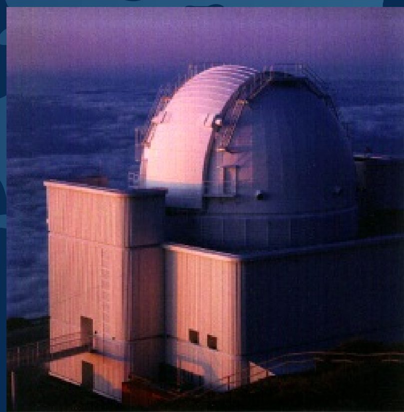
Graphics and Design: G. Cañada

Edited by: Gabinete de Dirección del IAC

January 2001

The mountain tops of the islands of Tenerife and La Palma in the Canarian archipelago belong to a select number of sites in the world where conditions are ideal for astronomical observations. The quality of the skies has attracted some of the "world's most modern" and powerful telescopes.

OBSERVATORY	TEIDE (OT)	ROQUE DE LOS MUCHACHOS (ORM)
Location	Tenerife (Canary Islands/Spain)	La Palma (Canary Islands/Spain)
Surface area	50 hectares	189 hectares
Altitude	2.390 metres	2.396 metres
Longitude	16° 30' 35" West	17° 52' 34" West
Latitude	28° 18' 00" North	28° 45' 34" North



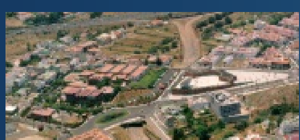
International Scientific Committee http://www.iac.es/gabinete/cci/index.html

RELEVANT CONTACTS IN RELATION TO THIS WORK

OT (TENERIFE)
Phone: 34-922-329100
Fax: 34-922-329117
e-mail: teide@ll.iac.es
http://www.iac.es/ot/indice.html

THÉMIS
Phone: 34-922-329148
Fax: 34-922-329145
Instituto de Astrofísica de Canarias
Vía Láctea s/n
E-38200 La Laguna, Tenerife
http://www.iac.es/gabinete/oteide/themis/themis.html

Vacuum Tower Telescope (VTT)
Kiepenheuer-Institut für Sonnenphysik (KIS)
Schöneckstr. 6, 79104 Freiburg
Deutschland
http://www.kis.uni-freiburg.de/kiswwwe2.html



INSTITUTO DE ASTROFISICA DE CANARIAS (IAC)
C/ Vía Láctea, s/n
E38200 La Laguna. Tenerife. España
Phone 34-922-605200
Fax 34-922-605210
e-mail: POSTMASTER@ll.iac.es

ORM (LA PALMA)
Apartado de Correos 303
E38700 Santa Cruz de La Palma
Phone: 34-922-405500
Fax: 34-922-405501
e-mail: adminorm@ll.iac.es
http://www.iac.es/gabinete/orm/orm.htm

Isaac Newton Group of Telescopes (WHT, INT, JKT)
Apartado de Correos 321
E-38700 Santa Cruz de la Palma
Canary Islands, Spain
Phone switchboard (sea-level office): 34 922 425400
ING reception (mountain-top): 34 922 405655
General fax (sea-level office): 34 922 425401
http://www.ing.iac.es/

Telescopio Nazionale Galileo (TNG)
P.O.Box 565
Roque de Los Muchachos Astronomical Observatory
E- 38700 Santa Cruz de La Palma
Canary Islands, Spain
http://www.tng.iac.es/

Nordic Optical Telescope (NOT)
Apartado de Correos 474
E-38700 Santa Cruz de La Palma
Canary Islands, Spain
Phone switchboard (sea-level office): 34 922 425 473
Fax (sea-level office): 34 922 425 475
http://www.not.iac.es/

For comments and suggestions please contact *cmt@ll.iac.es*